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DOWNY MILDEW ON LIMA BEANS

Supplement 257 June 15, 1959

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THE PLANT DISEASE REPORTER

MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch Plant Industry Station, Beltsville, Maryland

DOWNY MILDEW ON LIMA BEANS

Plant Disease Reporter
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THE HISTORY AND ECONOMIC IMPORTANCE OF THE LIMA BEAN DOWNY MILDEW DISEASE

Frank App[1]

Downy mildew on lima beans was first reported by Prof. R. Thaxter in the Annual Report of the Connecticut Agricultural Experiment Station in 1889. Prof. Thaxter gave a scientific description of the fungus, Phytophthora phaseoli, and illustrated in detail the summer stage but did not discover the winter stage. His successor, Dr. W. C. Sturgis, reported successful control of the disease with Bordeaux mixture in 1898, along with some of the conditions that influenced the dissemination of the pathogen, such as insects and wind.

Dr. B. D. Halsted reported a serious outbreak of downy mildew on lima beans in Bergen County, New Jersey, in the Annual Report of the New Jersey Agricultural Experiment Station for 1897.

Dr. C. O. Smith, of the Delaware Agricultural Experiment Station, reported its appearance in that State in 1904.

Reports from the New Jersey Agricultural Experiment Station, beginning in 1914, show that the disease was present in the State nearly every year.

We must credit these botanists for their discovery and description of the disease and the associated pathogen long before it became of great economic importance. Lima beans, at that time, were mostly a garden crop. It was not until the early 1900's that they became economically important and were grown as a field crop, for processing as well as for sale on the fresh market. Although the early botanists and pathologists reported control with Bordeaux mixture, commercial growers failed to use controls because of cost, lack of equipment, or insufficient information as to timing and the need for thorough coverage. These early reports were for occurrence on Fordhook lima beans.

The first production of baby lima beans for processing in New Jersey was by Brakeley Bros. of Freehold. According to Mr. Duryee, the first County Agent in the county in which Freehold was located, this was sometime in the 1890's. Brakeley Bros. had developed an outstanding processing unit and at their peak were producing approximately 3,000 acres of lima beans, all of which were processed in the plant at Freehold. They liquidated their company in the winter of 1927-28. They were growing lima beans continuously, without rotation, and when downy mildew became a major factor in production they were unsuccessful in developing a satisfactory control. They renewed their operations in Delaware where downy mildew was not then a problem.

The Stevens Canning Co., of Bridgeton, New Jersey, began canning beans in 1897, and the Ayars Canning Co., also of Bridgeton, early in 1900. Both of these companies discontinued during or before the early 1930's. The operation at Seabrook Farms began in 1918. Downy mildew became a major problem in the 1940's.

Drs. J. W. Heuberger and D. F. Crossan, University of Delaware, reported that growers in Delaware in 1958 suffered an estimated loss from 11,675 acres of 2,510,884 pounds of lima beans, valued at $175,762. Seabrook Farms, where relatively little loss occurred in 1958, followed a spraying program based upon results from research and development projected in 1948. (Table 1). The contract growers, on the other hand, who were not prepared with equipment to follow such a program, had heavy losses, with considerable abandoned acreage.

The Thaxter variety will be grown almost entirely in 1959. Unless Strain B of the causal organism, which was first discovered in 1958, appears, no control measures will be necessary. Our Fordhook type bean, however, is becoming a very important crop, and until a downy mildew-resistant Fordhook is available commercially, control measures will be necessary for it.

Dr. Heuberger reported downy mildew on Henderson bush lima beans in Delaware in 1945. Between 1945 and 1949 the disease twice threatened to wipe out the baby lima bean crop, which occupied the largest acreage of any vegetable grown in the State. Dr. Heuberger initiated experimental control measures with various fungicidal sprays and dusts, beginning in 1946.

In 1948, Seabrook Farms invited representatives from the United States Department of Agriculture, University of Delaware, Rutgers University, University of Maryland, and the New York State (Geneva) Experiment Station, to meet for the purpose of appraising the importance of controlling downy mildew on lima beans and to arrive at an agreement as to objectives and procedures for developing commercial control methods. The data submitted showed that downy mildew had become a major agricultural problem. For example, in 1946, Seabrook Farms

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[1] Director of Research (Emeritus) and Technical Advisor, Seabrook Farming Corporation.

Table 1. Estimated losses from lima bean downy mildew at Seabrook Farms, 1945 to 1952.

Year	Loss ($)	Dusting costs ($)
1945*	58,464.23	--
1946	120,841.33	16,000.75
1947	no mildew	--
1948	454,743.47	26,704.60
1949	89,839.34	441.20
1950	359,669.44	11,457.30
1951	132,972.24	29,961.20
1952	37,294.01	43,704.95

*Seabrook Farms acreage only--other years included contract acreage of growers.

abandoned over 1200 acres of beans because of the disease; in 1948, infection again was quite severe. Similar experiences were reported from the neighboring States.

The conference was unanimous that research should be organized, with the following objectives: 1) to develop downy mildew-resistant lima beans through plant breeding; 2) to determine how the causal organism is carried over from year to year; 3) to determine the length of time between infection and appearance of symptoms; 4) to determine the climatic conditions necessary for the development and spread of the disease; 5) to investigate the feasibility of control by use of fungicidal sprays and dusts.

At the request of the representatives from the Universities of Delaware and New Jersey, Dr. W. J. Zaumeyer, Principal Pathologist, and his associates from the United States Department of Agriculture, agreed to conduct the necessary research on the breeding of a downy mildew-resistant lima bean. Dr. Heuberger agreed to conduct research on manner of carryover from one year to the next, and to set up research projects for the field testing of control measures, including various fungicides, proper timing and method of application, and the efficiency of both sprays and dusts.

Dr. R. A. Hyre, Regional Plant Pathologist of the Department of Agriculture, stationed at the University of Delaware, agreed to set up a forecasting service based upon climatic conditions, to warn the growers when initial infection would occur and when to begin spraying or dusting for proper control.

Seabrook Farms was already conducting research on the use of various fungicides, including the timing and method of application, and the thoroughness of coverage by different methods of application, and offered to cooperate with any of the institutions in the proposed control studies as well as in the development of a forecasting service. In addition, the Department of Agriculture's resistant hybrid beans were tested by Seabrook Farms. Testing was first for observation, then for yield in trial plots, and finally the hybrids were grown in pilot plantings. The crops were processed and rated for quality and appearance.

As a result of this cooperative project, in the spring of 1958 the Department of Agriculture released a downy mildew-resistant baby lima bean named Thaxter, which is now going into commercial production. We now have effective control measures and equipment for the proper application of the fungicides. We know how the fungus carries over from one year to the next. From correlation with climatic conditions, we can forecast with reasonable accuracy when downy mildew will occur. In addition, the Department of Agriculture, through Dr. Zaumeyer and Mr. Wester, have a downy mildew-resistant Fordhook nearly ready for commercial introduction.

The pooling of information, both farm and institutional, and the fixing of responsibilities for developing the objectives agreed upon, has resulted in a gratifying achievement. Usually, agriculture is at a disadvantage because of the segregation of its functions: for each person working on the farm, there are two others working off the farm. This situation makes it desirable for all groups to cooperate as a unit in undertakings, such as this one, in which there is a mutual interest.

SEABROOK FARMING CORPORATION

THE DEVELOPMENT OF A METHOD FOR FORECASTING DOWNY MILDEW OF LIMA BEAN

R. A. Hyre[1]

Abstract

A method has been developed for forecasting downy mildew of lima bean (due to Phytophthora phaseoli) from rainfall and temperature data. Initial appearance of downy mildew is forecast after about 8 consecutive downy mildew-favorable days, and continuing downy mildew-favorable weather. A day is considered favorable for downy mildew when the 5-day moving mean temperature, ending on the fifth day, is less than 79°F, with the minimum temperature 45° or above; and the 10-day total rainfall, ending on the tenth day, is about 1.2 inches, or more.

At a conference held at the Seabrook Farming Corporation, Seabrook, New Jersey, in September, 1948 (1) it was agreed that a reliable method of forecasting lima bean downy mildew, due to Phytophthora phaseoli, would be a valuable aid in its control. The responsibility for developing such a method was assigned to the writer. At the same time, the downy mildew records of the Seabrook Farming Corporation were made available for this purpose. These records were later used in the development of the forecast method, and appreciation for permission so to use them is hereby expressed.

The first task was to study the physiology and life history of the causal organism, in order to determine the effect, particularly, of temperature and moisture on the development of the organism and the disease. About this time Harold T. Cook published a method for forecasting epiphytotics of late blight of potato and tomato (2), in which he used "moving charts" of daily rainfall and temperature data for determining critical disease periods. His moving chart method was modified and adapted by the writer to form the basis of the method presently in use for forecasting not only downy mildew of lima bean but also late blight of potato and tomato in the northeastern United States. Other methods, involving relative humidity and dew, are under investigation to supplement the rainfall-temperature method.

The method, as used for downy mildew of lima bean, has been described in detail in a recent publication (3). Briefly, it is as follows: For downy mildew to occur, both rainfall and temperature must be favorable simultaneously. Rainfall is considered favorable when the 10-day total is about 1.2 inches or more. Temperature is considered favorable when the 5-day mean is less than 79°F. Any day is considered unfavorable, however, if the minimum temperature is less than 45°. Moving graphs, calculated from daily weather data (usually obtained from the United States Weather Bureau), are maintained and the disease is forecast after about 8 consecutive mildew-favorable days, if the weather at that time remains favorable for the disease. Downy mildew, then, is expected to appear 1 or 2 weeks later.

Figure 1 is an analysis of 13 years of weather and downy mildew data for southern New Jersey. On it are shown the periods of downy mildew-favorable weather, the dates when downy mildew was first observed, and the estimated severity of the disease for the season. There is a good correlation between the first weather periods of 8, or more, consecutive favorable days and the date of first observation of the disease. There were 2 years of no significant mildew. In 1947 there were no favorable weather periods, and no disease was observed. The year 1957 was very dry and all beans were harvested early -- "prior to September 30"; although no downy mildew was seen before harvest mildew-favorable weather occurred just prior to harvest and a a little mildew was observed after harvest, on October 4. During 8 years when downy mildew was rated severe (62 percent of the years) both the time of first observation and the subsequent severity of the disease correlated very well with the mildew-favorable weather periods. Likewise, for the 3 years when mildew was light good correlation between disease incidence and mildew-favorable weather periods was evident. In 1953, a warm period followed the first 8-day favorable weather period and apparently stopped the the development of mildew at that time.

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[1] Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, University of Delaware, Newark, Delaware.

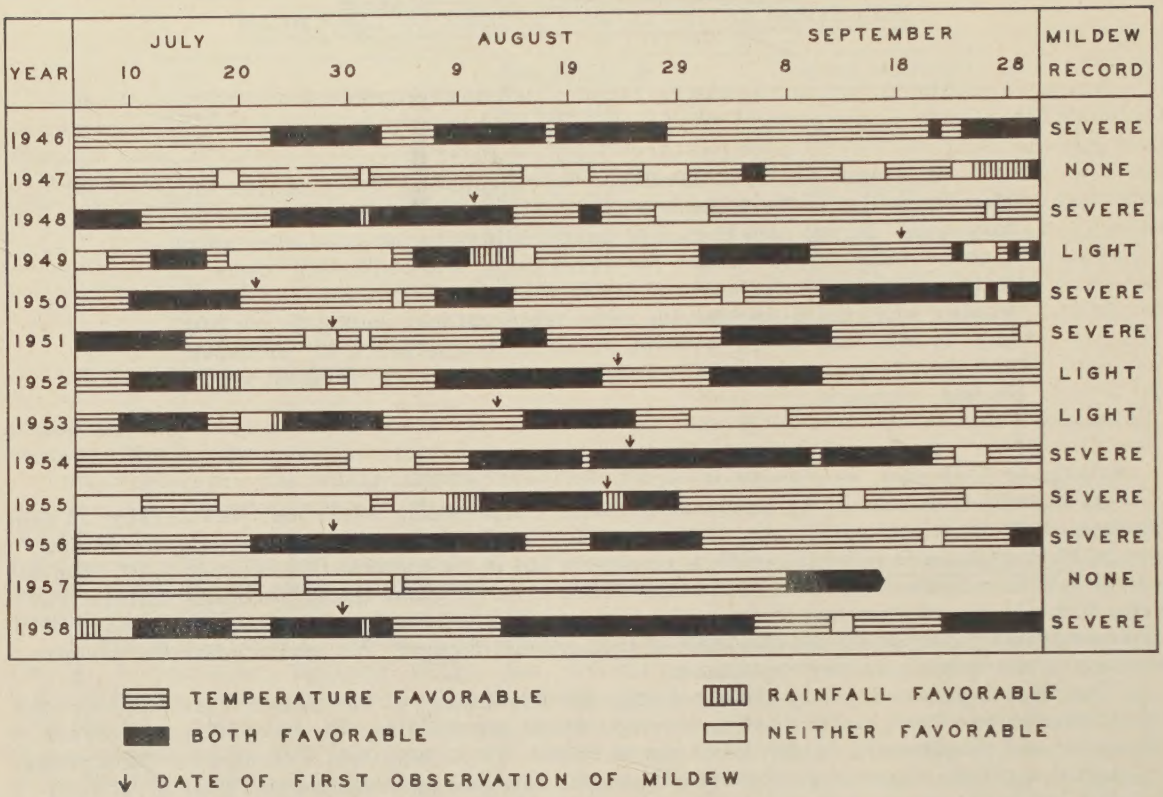

FIGURE 1. Summary of July-September temperature and rainfall data for Bridgeton, New Jersey, in relation to the importance of downy mildew of lima bean, 1946-1958 inclusive.

Downy mildew has been forecast for 6 years with good accuracy. The forecast area has been extended to the principal green lima bean areas in the northeastern United States, and includes the States of New York, New Jersey, Delaware, Maryland, and Pennsylvania.

The forecast method is defined in rather precise terms, but a degree of flexibility is desirable in applying the criteria in some situations; for instance, when a series of sub-minimal favorable periods occur closely together, or in isolated locations favorable for mildew. With experience such situations should cause little trouble.

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BREEDING LIMA BEANS FOR RESISTANCE TO DOWNY MILDEW

R. E. Wester[1] and Robert C. Cetas[2]

A program of breeding lima beans resistant to the downy mildew fungus (Phytophthora phaseoli Thaxt.) was begun by the United States Department of Agriculture in 1948 in cooperation with the Long Island Vegetable Research Farm at Riverhead, New York. In tests of most domestic lima bean varieties and foreign plant introductions, resistance was located in four unnamed lines. These lines originated from India, Guatemala, southeastern United States, and California.

The first crosses between the downy mildew-resistant parents and Early Thorogreen and Fordhook 242 lima beans were made at the Plant Industry Station, Beltsville, Maryland, in the spring of 1949. It was discovered that the inheritance of resistance was controlled by a single dominant gene (2).

After three backcrosses to Early Thorogreen followed by seven generations of selection and testing for downy mildew resistance in the greenhouse (Fig. 1) and in the field, an outstanding resistant line was chosen. It was named Thaxter for the late Roland Thaxter, an eminent plant pathologist who first discovered the lima bean downy mildew fungus and described it (1) in 1889. The downy mildew-resistant parent of Thaxter was U. S. Department of Agriculture P.I. number 164155, a colored-seeded pole lima bean from Nagpur, India.

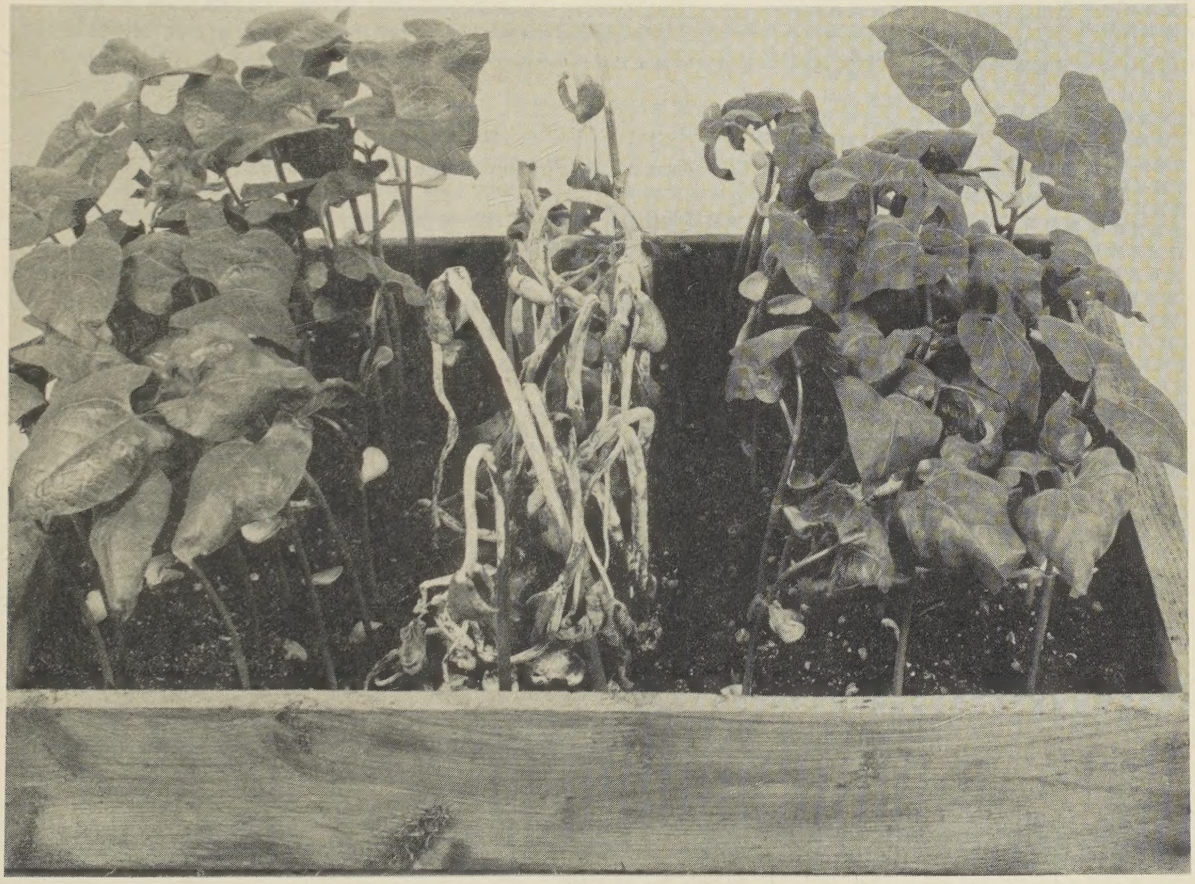

FIGURE 1. Early Thorogreen seedlings (center) killed by downy mildew strain A, while Thaxter seedlings (right and left) are highly resistant.

[1] Horticulturist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland.

[2] Associate Professor of Plant Pathology, Cornell University, Long Island Vegetable Research Farm, Riverhead, New York.

In 1958 about 20,000 pounds of seed of Thaxter was produced by seedsmen from breeders' stock furnished by the United States Department of Agriculture for increase. It is possible that as much as 500,000 pounds may be available for planting in 1959.

In preliminary trials in 1954 and more extensive ones from 1954 to 1958 Thaxter was found to be well suited for processing. The tests showed that it was very productive and well adapted for vining. It was tested extensively in the lima bean-growing areas of Delaware, Maryland, New Jersey, and Pennsylvania, where downy mildew is frequently widespread, and until 1958 it always showed a very high degree of resistance to all collections of the downy mildew fungus. In the fall of 1958, however, a new race of the fungus known as race B (3) was discovered in New Jersey. Greenhouse tests have shown that Thaxter is susceptible to it. It cannot be predicted at this time, however, whether the new race will become widespread in future years.

Resistance has been incorporated into lines of the Fordhook type, in addition to Thaxter. Five or six backcrosses have been necessary to produce the desired type. Several promising lines, which have been resistant to downy mildew in both greenhouse and field tests since 1956, have been developed. Like Thaxter, however, these lines are susceptible to the new race B of the mildew organism.

As soon as race B was discovered, the U. S. Department of Agriculture started to test all the recent foreign plant introductions of lima beans, hoping to find resistance to it. Fortunately, P.I. No. 189403, named Piloy, from Guatemala was found to be highly resistant to this new race of downy mildew as well as to race A, which is very widespread. Piloy, a vigorous, highly productive, bush type with small, flat, red seed has been crossed with Thaxter, Fordhook 242, and USDA No. 551, a new Fordhook-type lima bean. It is hoped that Piloy, in addition to contributing resistance to downy mildew races A and B, may also contribute other genes for the improvement of Fordhook 242 and commercial baby lima beans.

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UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, AND CORNELL UNIVERSITY

CONTROL OF LIMA BEAN DOWNY MILDEW BY FUNGICIDES[1]

J. W. Heuberger and D. F. Crossan [2, 3]

Abstract

This paper is the fourth in the series in this Plant Disease Reporter Supplement, summarizing cooperative work in the Jersey-Delmarva area on various aspects of the downy mildew disease of the Henderson bush lima bean. It covers the aspect of control by the use of fungicides. Thirteen years of research on copper and organic fungicides are reviewed briefly. Maneb (2-100) was found to be the most effective of the fungicides tested when used as a spray. Two years of commercial custom spraying have substantiated the research results.

INTRODUCTION

Downy mildew (Phytophthora phaseoli) of the Henderson bush lima bean[4] was first found in Delaware in 1945, even though the disease had been known to occur on the Fordhook bush lima in Delaware since 1905. Recognizing the potential seriousness of the disease to the Henderson lima bean industry (approximately 22,000 acres) in Delaware, particularly in view of what happened in New Jersey (2), the Experiment Station started a research program on the use of fungicides as sprays and dusts for control. Experiments have been conducted yearly since 1946 (4, 6, 7, 8).

Surveys of losses were made from time to time in Delaware, based on an estimate of percentage of the crop lost. Results were, at best, somewhat unsatisfactory. Therefore, in the fall of 1958, a questionnaire on losses from the downy mildew disease, prepared in such a way that fairly accurate information was needed to answer the questions, was sent to the lima bean processors. Replies received covered a total of 11,675 acres, more than half the total acreage in the State. Based on an average yield of 1600 pounds of shelled beans per acre, losses were as shown in Table 1.

Table 1. Estimated losses from lima bean downy mildew, 1958.

Acres included	Loss in shelled beans	
	Pounds/Acre	Total Pounds
280	200	56,000
275	250	68,750
95	600	57,000
231	714	164,934
1025	800	820,000
50	900	45,000
812	1600	1,299,200
		2,510,884

At a value of 7¢ per pound, the loss of 2,510,884 pounds amounted to $175,762. This represented a loss on 11,675 acres of approximately 14 percent.

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[1] Published with the approval of the Director of the Delaware Agricultural Experiment Station. Contribution No. 117 of the Department of Plant Pathology.

[2] Professor and Assistant Professor, respectively.

[3] The writers wish to acknowledge their indebtedness to the following lima bean processors whose unstinting cooperation made their work possible: H. P. Cannon and Son Co.; W. L. Wheatley Co.; Libby, McNeill, Libby Co.; Draper Canning Co.; and the Stokely Canning Co.

[4] Also commonly known as the "baby" lima bean.

LITERATURE REVIEW

A review of the literature on control of downy mildew of lima beans on the Atlantic coastal plain soils showed only a few reports, mainly on the Fordhook variety. Sturgis (9), in 1897, recommended spraying with Bordeaux mixture. Clayton (3), in 1928, reported on his extensive experiments with Bordeaux mixture on Fordhook on Long Island. His data showed that good control was obtained with five applications, two before bloom and three after bloom, and that spraying did not noticeably discolor the pods. In 1947, Cunningham (5) reported his 6-year study on control by fungicides. He found that spraying or dusting, on a regular schedule, with copper fungicides gave control; that the copper fungicides did not noticeably discolor the pods, but copper injury in the form of rusty-brown spots did occur in transit if the beans were picked and packed when wet; that Bordeaux mixture caused some foliage injury; and, that of the organic fungicides tested (ferbam, Spergon, Phygon, Dithane D-14 plus zinc sulfate and lime), only Dithane D-14 plus zinc sulfate and lime gave control equal to that obtained with the copper fungicides.

Prior to the work in Delaware, the only previous research on control of downy mildew on the Henderson bush lima was that conducted by the Department of Plant Pathology, New Jersey Agricultural Experiment Station, Rutgers University, during the period 1939-1943 inclusive (1). Various fungicides, including several copper materials, were tested as sprays and dusts. No information was obtained on downy mildew control as that disease was not present; however, striking data were obtained on copper injury. It was found that the Henderson bush lima was far more sensitive to copper than the Fordhook bush lima; in some cases, the yield of Henderson lima beans receiving copper fungicides was reduced 27 to 54 percent as compared with yield from untreated plants. The following conclusion was reached: "Under New Jersey conditions, where the bean diseases controllable by sprays or dusts are of minor importance, it would seem advisable to avoid the use of copper on these crops entirely and limit the applications to insecticides, except in specific cases where downy mildew threatens to become a serious problem on late lima beans"

REVIEW OF RESEARCH IN DELAWARE

During the period 1946-1948, inclusive, experiments were conducted at Thompsonville on various copper and organic fungicides, used as dusts and sprays (6). Unfortunately, the disease did not become serious enough in the plots to obtain control data; however, data were obtained on plant injury and yield, as follows:

1. Bordeaux spray was injurious and markedly reduced yield.
2. Fixed coppers were injurious and reduced yields when used as sprays but not when used as dusts.
3. Zineb (Dithane Z-78; Parzate) was non-injurious and did not reduce yield, either as sprays or dusts.

In 1949, a total of 17 tests were conducted in the Bridgeville, Thompsonville, Milton, and Rehobeth areas on plantings of various ages (7). The mildew did not develop until October when it appeared in the last three tests on late-planted beans. Results were summarized as follows:

1. Copper sprays (Bordeaux; Tribasic) gave excellent disease control but were injurious. Tribasic Copper dust gave good disease control and did not reduce yield.
2. Zineb sprays (Dithane Z-78; Parzate) were not quite so effective in control as the copper sprays and did not reduce yield. As dusts, these materials were less effective in control than sprays.

During 1950, tests were conducted to determine: (a) if the mildew could be controlled when fungicide applications were begun after the disease appeared, and (b) the effect of the number of applications on control (7). The data obtained showed that the disease could be controlled after it first appeared in small amounts, provided that applications were begun immediately. Also, as the number of applications increased, control increased.

While this work was in progress, growers were not successful in controlling downy mildew by the use of dusts applied either by plane or helicopter; however, where ground equipment was used, some control was obtained provided the incidence of mildew was not too high when dusting began.

Thus, by the end of 1950, it was evident that a new chemical had to be found if growers were to obtain control by the use of fungicides. Accordingly, beginning in 1951, maneb was included in the test plots; and, in 1956, streptomycin (10) was included. In 1956, downy mildew developed in sufficient quantities so that excellent control and yield data were obtained in two plots (4). A brief comparison of the results from maneb, Tribasic Copper Sulphate, and streptomycin is given in Table 2.

Table. 2. Comparison of results from 1956 tests for control of lima bean downy mildew.

Material[a]	Concentration	Percent infected pods		Pounds shelled beans /acre	
		Test #1	Test #2	Test #1	Test #2
Untreated		38.0	34.0	2523	1842
Maneb	2-100 lb./gal.	0.4	1.0	3819	3991
Tribasic	4-100 lb./gal.	9.0	2.0	3248	3435
Streptomycin	100 ppm	25.0	14.0	2438	2282

[a] In Test #1, the first application was made when the disease was first beginning to develop (August 31); it was followed by a second application on September 12. In Test #2, the disease appeared about September 2. Applications were made on September 5, 13, and 20.

Subsequent tests in 1947 and 1958 confirmed the data above that maneb, used as a spray, is very effective in control of downy mildew and that its use results in high yields. Recent grower experience in New Jersey has indicated that maneb is not satisfactory for control when used as a dust.

COMMERCIAL CONTROL

During 1957 and 1958, one lima bean processor in Delaware sprayed hundreds of acres with maneb (2-100) on a contract basis, using hydraulic ground sprayers. Results obtained showed that excellent commercial control was obtained where the applications were timed properly according to weather conditions. This resulted in high yields of beans of high quality. This processor made a study of the labor costs in the plant for sorting beans on the belts from unsprayed and sprayed fields. His findings showed that much less labor was required to sort the beans from sprayed fields, in fact, the savings in labor were enough to pay for the cost of spraying in the field.

Thus, two years of commercial use has shown that maneb, as a spray, increases yield and improves quality of the beans to the grower, insures the processor of a crop of high quality beans, and decreases the labor cost for processing the beans in the plant.

CONCLUSIONS

Now that an effective fungicide is available and an accurate downy mildew forecasting system is functioning, and growers must obtain control of insects also, there is no reason why growers and processors alike should not be prepared to spray their beans when downy mildew threatens. The first fungicide application should be tied in with the first mildew warning; subsequent applications should be determined by seasonal conditions. As all the insecticides used on beans are compatible with maneb, joint application can be made for downy mildew and insect control.

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DEPARTMENT OF PLANT PATHOLOGY, DELAWARE AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF DELAWARE